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"On the Behaviour of the Fixed Elements of the Connective Tissue of the Tongue in Inflammation." By GEORGE F. DOWDESWELL, B.A. Cantab. Communicated by J. BURDON SANDERSON, F.R.S., Professor of Physiology in University College. Received June 14, 1876*.

[PLATE 8.]

The connective tissue of the tongue of Batrachians was first studied, with reference to the changes which it undergoes in inflammation, by Prof. Cohnheim in 1869†. The animal employed by him was the ordinary edible frog (*Rana esculenta*). His mode of preparation was as follows:—A plate of glass about 3" by 5" was first prepared, having a smaller oblong plate, measuring 1" by 0".7, cemented to it with Canada balsam at one end. This was surrounded by a cork ring border of the same thickness. On this plate the body of the frog (previously curarized) was placed, resting on its back, in such a position that the tongue could be readily extended over the oblong plate with the aid of

* Read June 15, 1876. See *ante*, p. 272.

† Cohnheim, "Ueber das Verhalten der fixen Bindegewebskörperchen bei der Entzündung," Virchow's 'Archiv,' vol. xlvi. p. 333.

pins stuck into the cork ring. As thus displayed, the smooth surface of the organ of course rested on the glass, the papillary surface looking upwards.

To expose the submucous tissue, Cohnheim found it necessary to divide the mucous membrane to the extent of an eighth of an inch; by doing so he was able to obtain a sufficient surface for microscopical examination, in which, if care was taken to keep it constantly moist with serum and to avoid undue stretching, the circulation could be observed for many hours. Although, as compared with the one to be immediately described, the method was imperfect, it was much superior to any which had been employed before for the study of the textural changes which are associated with the process of inflammation.

In the stratum of tissue thus exposed, the objects which first attract attention are, it need scarcely be said, the arteries, veins, and capillaries, and the rapidly circulating blood. In addition to these, various fibrous structures present themselves, namely striped muscular fibres, single or in groups, some entire, others broken; nerves, each consisting of a variable number of dark-bordered nerve-fibres, bundles of white fibrous tissue, and very numerous single fibrils. In the spaces between these structures a number of bodies are seen scattered without apparent regularity in the fine transparent membrane of areolar tissue. With reference to these bodies, which were first described by Cohnheim, and constituted the principal subject of the paper now referred to, he remarks that although they differ considerably in form and appearance from the fixed elements of areolar tissue elsewhere, they can only be regarded as "connective-tissue corpuscles."

Cohnheim found that when this tissue, immediately after having been exposed in the manner above described, was observed continuously for many hours under the microscope, the circulation became much accelerated, and the vessels (veins and arteries) became dilated. Soon the dilatation of the arteries diminished, while the motion of the blood became slower, especially in the veins of which the diameter was still larger than in the natural state. In a short time the colourless corpuscles began to hug the walls of the veins, and soon after emigration set in with great vigour. As this went on, it was seen that in numerous capillaries stasis was either commencing or complete, a state of things which rapidly led to diapedesis, affecting both capillaries and veins.

These facts having been ascertained, and being moreover in complete accordance with what Cohnheim had himself described in inflamed parts elsewhere, it remained to inquire what part the fixed elements played in the active changes going on around them. For our present purpose it is sufficient to state that Cohnheim concluded that they took no part whatever in those changes; and he used this fact in support of his general position, that fixed elements of tissues do not participate in any inflammatory processes of which those tissues may be the seat.

But since 1868, as is well known, Cohnheim's conclusions on this sub-

ject have been warmly disputed. On the one hand the pathological histologists of the Vienna School have maintained, on the basis of much laborious work done by Prof. Stricker and his pupils, the previously received belief as to the textural origin of those young cells the presence of which is the most essential characteristic of inflammation. On the other hand Cohnheim, supported by Axel Key and many others, has strengthened his view of the case by extending the research in new directions.

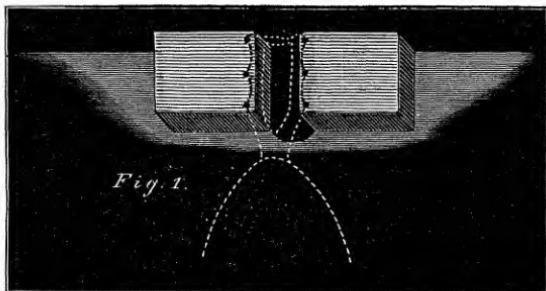
As regards the tongue of the frog, Prof. Stricker has published observations in which, following Cohnheim's own method, he arrived at opposite conclusions.

I have thought it desirable to publish the observations here recorded, because the methods now adopted appear preferable to any previously employed, the tongue of the toad being much better adapted for the study of the tissues than that of the frog.

The organ, when protruded, extends nearly an inch out of the mouth; and in this state exhibits near the mouth the form of a flattened cylinder, of which the cross section is oval. Towards its extremity it becomes flattened, and exhibits a tendency to bifurcation, ending in two short tips, often called cornua. Of its two principal surfaces, of which one is beset with papillæ, the other smooth, the former (supposing the animal to be in the supine position) is undermost. But when the organ is retracted, and occupies its usual position in the mouth, it is bent back in such a way that the papillated surface looks towards the palate.

The arrangement and anatomical relations of the structures which constitute the substance of the tongue may be most readily understood by the examination of transverse sections. In any vertical section of a properly hardened tongue across the thicker part of the organ it is seen that immediately underneath the mucous membrane of the smooth surface there is a large cavity, which, from its lining of flat cells, the anatomist at once recognizes as a lymph-sac. The floor of this lymph-sac is formed towards the middle line by a mass of muscular fibres, of which the direction is longitudinal, and from which the liquid contents are only separated by the cellular lining. The under surface of the muscular mass is also covered by cells which form the lining of a second lymphatic cavity, which is in a similar relation to the papillated mucous membrane to that in which the principal lymph-sac stands to the mucous membrane of the smooth surface. There is, however, between the lymphatic cavity and the mucous tissue a superficial stratum of muscular fibres. In fresh preparations it can be easily made out that the deeper muscular fibres, which are nearest the attachment of the tongue, form a single bundle on either side of the middle line, spread out towards the double tip in finger-like processes having spaces between them. Through these spaces the two lymphatic sacs freely communicate, so that when liquid is injected into either sac, the other also becomes distended.

In my method of observation I followed in the main that employed by Prof. Cohnheim. That method was, however, modified in the following important particulars:—1. The toad being preferred to the frog on the grounds already stated, I found it necessary to employ very much larger quantities of curare. The dose used by Cohnheim did not exceed 0·001 grain, a quantity which is well known to be sufficient for the frog. But in the toad I found that 0·004 grain was required, and that it was necessary to repeat the injection every 36 or 48 hours during the course of each observation. 2. The support on which the body of the animal



Outline sketch of the cork support used in all the experiments (actual size). The dotted lines represent the outline of the tongue and head.

rested was not of glass, but of cork. On either side of it is a block of cork, which answers the purpose of Cohnheim's cork border. The small oblong plate of glass used by him is dispensed with. 3. In order to prepare the tongue for observation, it is necessary first to distend the lymph-sac by injecting into it $\frac{3}{4}$ -per-cent. solution of common salt with the aid of a hypodermic syringe, and secondly to divide the mucous membrane which constitutes its roof with fine scissors. This having been accomplished, the cut edges are drawn aside so as to expose the surface of the septum of muscular fibres which divides the lymph-sac into two parts. A well-lighted field is thus obtained, in which the most delicate details of structure can be satisfactorily observed, even under high powers.

The injury thus inflicted on the organ is so trifling that, provided that care has been taken to guard against the production of hæmorrhage, there is at first no evidence of any pathological disturbance. Soon, however, the changes (of which an account has been already given) begin to present themselves, the several phenomena following each other in the order in which they were originally described by Prof. Cohnheim. I would only remark that the vascular changes can be studied very advantageously, and in particular that the process of emigration displays itself before the observer with wonderful beauty and distinctness.

As in my observations I confined myself entirely to the behaviour of the fixed elements of the tissue, I shall say nothing more of the vascular

changes, the interest of which to me consisted principally in that their presence afforded the evidence that the part observed was in a state of active inflammation. The question I had to answer was, whether or not this state, even when prolonged, is attended with any change whatever in the anatomical characteristics of the preexisting elements.

For this purpose more than a dozen series of observations were made on as many different animals, each series being continued for several days. At the beginning of each series a group of connective-tissue corpuscles, such as the one represented in Plate 8. figs. 3 and 4, was selected and (with the vessels and other structures in relation with it) accurately drawn with the aid of the camera lucida. The preparation was then removed from the microscope and placed in a vessel in which the air was kept saturated with aqueous vapour. The next day, after removing the layer of exuded colourless corpuscles (*pus*) which covered the exposed surface of the lymph-sac, by directing upon it a gentle stream of salt solution, the outlines of the group of connective tissue were again traced with the aid of the camera.

In this way several daily observations were taken in respect of each animal. It usually happened that on the fourth or fifth day the circulation became impaired or ceased; but in one instance it continued in vigour as long as nine days, during the whole of which period the same group of corpuscles was kept from time to time under observation.

The result may be stated in a single line. So long as the circulation continued, "no change whatever took place in the connective-tissue corpuscles, either as regards form or appearance," notwithstanding that the tissue of which they formed part was beset with innumerable emigrant colourless corpuscles, *i. e.* (to use ordinary language) was infiltrated with *pus*.

In order that the reader may be put in possession of certain facts which have not been sufficiently noticed in the summary I have now given of the results of my investigation, I will add a few short notes relating to particular experiments.

The first two experiments differed from the others in this respect, that immediately after beginning my observations I touched the observed part with a drop of water acidulated with hydrochloric acid (1 part of strong acid to 100 of water). The vascular changes of the early stage exhibited themselves in intensity, and resulted in a very abundant emigration of leucocytes; but as the observation was only continued for two days, the results were of less value as regards the special question under investigation. The fixed corpuscles were remarkably distinct, and these underwent no alteration.

In the fifth experiment (see description of fig. 3) the observation was continued for 5 days, at the end of which period the animal was killed. At that time the connective-tissue corpuscles, which were distinct and presented very remarkable contours, remained entirely unchanged.

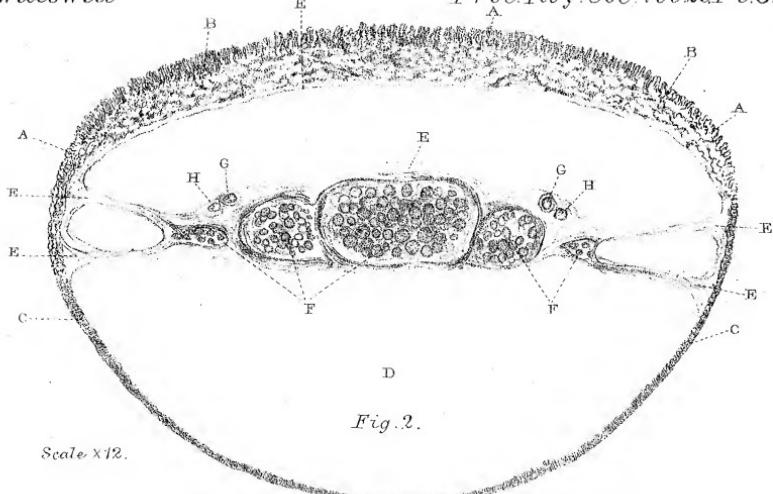


Fig. 2.

Scale, x12.

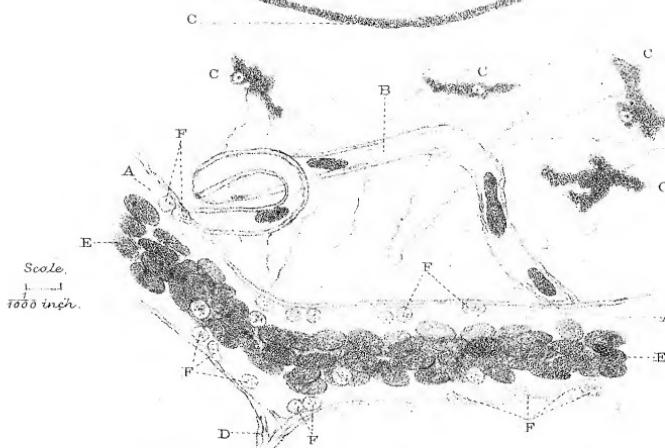


Fig. 3.

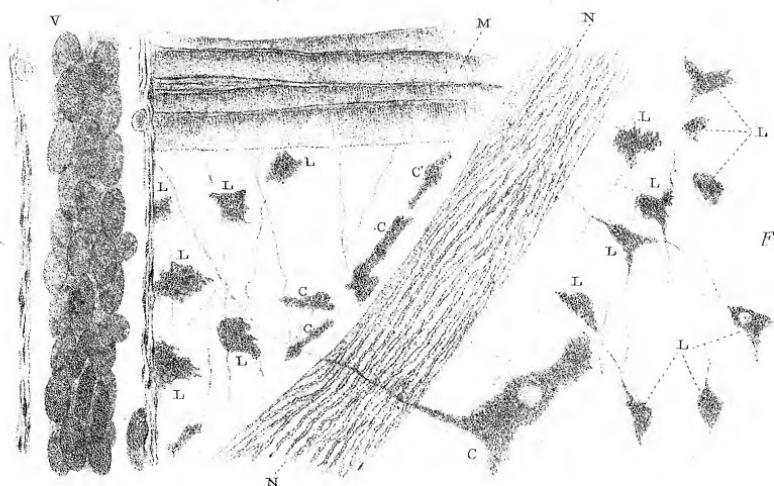
Scale,
1
1000 inch.Scale,
1
1000 inch.

Fig. 4.

In experiment 6 (see fig. 4) the observations were continued successfully for seven days, during the whole of which period the circulation was vigorous, although active emigration took place. Neither in this nor in any of the other cases was any extravasation of coloured blood-corpuscles, either from veins or capillaries, distinctly viewed. In this respect there may be a difference between the frog and toad.

In experiment 8 no exudation took place during the first day, the circulation going on apparently normally. Subsequently leucocytes began to escape, and exhibited their usual character and behaviour. The observation was continued for three days, but no change occurred in the fixed corpuscles.

In experiment 11 the observation was as successful as in experiment 6. The circulation was vigorous until the sixth day; emigration was abundant, and began immediately after the commencement of the observation. In the course of the sixth day it became feeble, and it was then observed that the connective-tissue corpuscles, although retaining their form, lost their transparency and became granular.

EXPLANATION OF PLATE 8.

Fig. 2. Diagram of vertical section of tongue, distended. A, papillated surface; B, sub-mucous muscular layer; C, smooth under surface of mucous membrane, forming wall of the larger lymph-sac, D; G, principal venous trunks; H, principal arterial trunks, which are accompanied by nerves not shown; F, F, muscular bundles; E, fine transparent membrane of connective tissue lining the lymph-sacs, and forming a continuous sheath to the bundles of muscular fibre. In this membrane are the fixed corpuscles, the subjects of observation.

Fig. 3. Field of view in Experiment 5 at the commencement of the observation. Emigration has not commenced, but in the vein A the leucocytes (F, F) begin to tend towards the internal surface of the wall. Through the capillary B a few coloured corpuscles are passing. C, C are the fixed corpuscles of the tissue. The fine lines are single fibres of connective-tissue. E, E are the red blood-corpuscles.

In this experiment, in which, as already stated, the observations were continued for five days (from Oct. 23 to Oct. 29), I was able to bring the same field into view from time to time during the whole period. The vein marked D was at the beginning of the observation obliterated, having been injured in preparation. Towards the third day blood began to pass through it, and soon the circulation in it was completely reestablished. In this case the connective-tissue corpuscles represented (C C C C) were watched with the most minute attention. Notwithstanding that the emigration was most abundant, so that before each observation it was necessary to cleanse the surface of the lymph-sac by irrigation, as above described, there was no alteration of form whatever, either in the corpuscles themselves or in their nuclei, nor did they exhibit the slightest tendency to divide.

Fig. 4 represents the appearances exhibited by a vein and the neighbouring textural elements, at a later stage. In the vein V, notwithstanding that the circulation is still vigorous, an abundant emigration is in progress. Some colourless corpuscles adhere to the walls, others have already escaped and are crossing the field, mostly clinging to the fibrils of connective tissue, and exhibit various

and active amoeboid movements. C, C are connective-tissue corpuscles, of which one is of such remarkable form and appearance that the least change in it could be very readily observed. It contains a conspicuous vacuole, and it sends its processes along the fibrils of elastic tissue, as formerly described. N is a small nerve-trunk. M, striated muscular fibres. L, L are leucocytes—migratory colourless blood-corpuscles.

This specimen was kept under observation for eight days, during the whole of which emigration continued. It remained absolutely unchanged, with the exception that the vacuole of the corpuscle above described varied somewhat in size. Thus on the fifth day it became somewhat more distinct than it had been before. About the same time highly refractive granules and bodies resembling *Bacteria* appeared, and the leucocytes present seemed also to contain granules. On the seventh day it was observed that the circulation was growing feeble, and the tissues were losing their transparency, a change in which the fixed corpuscles obviously participated. On the morning of the eighth day it was found that circulation had ceased.

December 7, 1876.

Dr. J. DALTON HOOKER, C.B., President, in the Chair.

The Presents received were laid on the table, and thanks ordered for them.

The following Papers were read :--

- I. "On a new Form of the 'Sprengel' Air-pump and Vacuum-tap." By CHARLES H. GIMINGHAM. Communicated by WILLIAM CROOKES, F.R.S. &c. Received August 30, 1876.

[PLATE 9.]

Having had the honour of being with Mr. Crookes during the whole of his recent researches on Radiation, and knowing the importance of obtaining the highest degree of rarefaction possible, I have latterly devoted much attention to the improvement of the "Sprengel" mercury-pump. Having now succeeded in constructing an instrument yielding very satisfactory results both in degree of exhaustion and rapidity of working, I purpose giving a detailed description of it, together with a new form of vacuum-tap which has been found exceedingly useful while working with vacua.

The instrument, owing to the number of accessories, at first sight appears complicated. I will therefore first explain the principle of the pump, tracing the mercury and exhaustion through the different tubes, and then describe each adjunct separately.

Assuming the pump to be empty, the reservoir A (fig. 1) is lowered till its support rests on the stop (S) at the bottom of the stand (as shown by dotted lines in the figure), the position of the latter being so arranged



Outline sketch of the cork support used in all the experiments (natural size). The dotted lines represent the outlines of the tongue and heel.

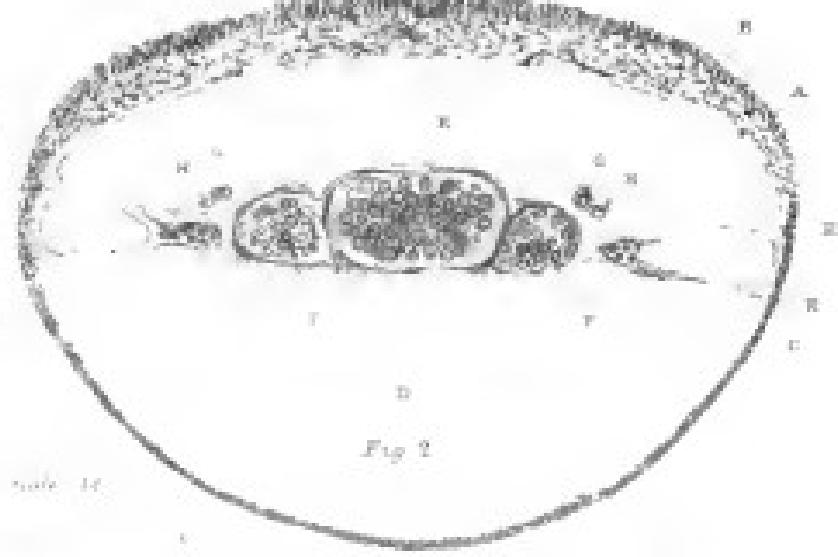


Fig. 2.



Fig. 3.

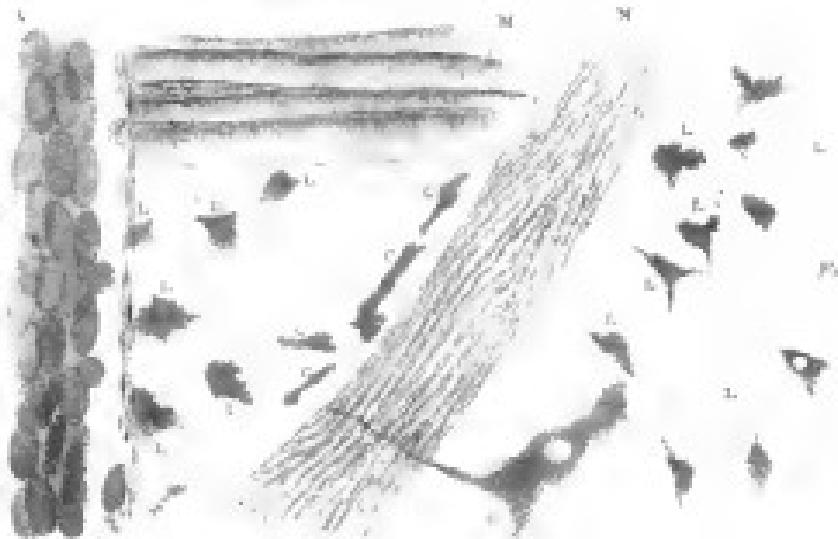


Fig. 4.

EXPLANATION OF PLATE 8.

Fig. 2. Diagram of vertical section of tongue, distended. A, papillated surface; B, submucous muscular layer; C, smooth under surface of mucous membrane, forming wall of the larger lymph-sacs; D, principal venous trunks; E, principal arterial trunks, which are accompanied by nerves not shown; F, muscular bundles; G, fine transparent membrane of connective tissue lining the lymph-sacs, and forming a continuous sheath to the bundles of muscular fibre. In this membrane are the fixed corpuscles, the subjects of observation.

Fig. 3. Field of view in Experiment 3 at the commencement of the observation. Emigration has not commenced, but in the vein A the leucocytes (E, F) begin to tend towards the internal surface of the wall. Through the capillary B a few colourless corpuscles are passing. C, C are the fixed corpuscles of the tissue. The fine lines are single fibres of connective-tissue. E, E are the red blood-corpuscles.

In this experiment, in which, as already stated, the observations were continued for five days (from Oct. 21 to Oct. 26), I was able to bring the same field into view from time to time during the whole period. The vein marked D was at the beginning of the observation obliterated, having been injured in preparation. Towards the third day blood began to pass through it, and soon the circulation in it was completely reestablished. In this case the connective-tissue corpuscles represented (C C C C) were watched with the most minute attention. Notwithstanding that the emigration was most abundant, so that before each observation it was necessary to cleanse the surface of the lymph-sac by irrigation, as above described, there was no alteration of form whatever, either in the corpuscles themselves or in their nuclei, nor did they exhibit the slightest tendency to divide.

Fig. 4 represents the appearances exhibited by a vein and the neighbouring technical elements, at a later stage. In the vein V, notwithstanding that the circulation is still vigorous, an abundant emigration is in progress. Some colourless corpuscles adhere to the walls, others have already escaped and are crossing the field, mostly clinging to the fibrils of connective tissue, and exhibit various and active amorphous movements. C, C are connective-tissue corpuscles, of which one is of such remarkable form and appearance that the least change in it could be very readily observed. It contains a conspicuous vacuole, and it sends its processes along the fibrils of elastic tissue, as formerly described. N is a small nerve-trunk. M, striated muscular fibres. L, L are leucocytes—migratory colourless blood-corpuscles.

This specimen was kept under observation for eight days, during the whole of which emigration continued. It remained absolutely unchanged, with the exception that the nucleus of the corpuscle above described turned somewhat in situ. Thus on the fifth day it became somewhat more distinct than it had been before. About the same time highly refractive granules and bodies resembling *Bacilli* appeared, and the leucocytes present seemed also to contain granules. On the seventh day it was observed that the circulation was growing feeble, and the tissues were losing their transparency, a change in which the fixed corpuscles obviously participated. On the morning of the eighth day it was found that circulation had ceased.